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Target-Acquisition Capability
Weapon-Laying Capacity

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Describes procedures for evaluating night performance of combat vehicles in the areas of mobility, interior illumination, fire control, and durability of illuminating components. Night fire control evaluation consists of prefiring and firing tests to determine the degradation due to darkness of the resolving power, target-detection range, weapon-laying and target-acquisition capabilities of the sighting systems, firing accuracy and dispersion.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-101
*Test Operations Procedure 2-2-616 8 May 1981
AD No.

NIGHT PERFORMANCE OF COMBAT VEHICLES

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1. SCOPE. This TOP describes procedures for evaluating night performance of combat vehicles in the areas of mobility, interior illumination, fire control, and durability of illuminating components. Night fire control evaluation consists of prefiring and firing tests to determine the degradation due to darkness of the resolving power, target-detection range, weapon-laying and target-acquisition capabilities of the sighting systems, firing accuracy and dispersion.

This test is normally conducted with both civilian and military personnel, the former to make a technical evaluation and the latter to introduce human factors. This TOP does not cover the operation and

*This TOP supersedes TOP 2-2-616, 13 September 1968.

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effectiveness of thermal imaging devices and other night vision devices. These are covered in TOP/MTP 3-2-706. 1/

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

ITEM	CHARACTERISTICS
Appropriate vehicular test courses 2/	As required
Standard vehicles test panels	White, two 25 x 25 cm (10 x 10 in.) against black background.
Automatic weapon targets	White, 6 m sq with 2.3 m black square in the center with white, 46 cm in diameter, circular bull's-eye; and 2.3 m sq with black, 46 cm in diameter, circular bull's-eye

Selected target vehicles to evaluate target-acquisition capabilities

2.2 Instrumentation.

ITEM	MAXIMUM PERMISSIBLE ERROR OF MEASUREMENTS*
Light meter(s) (Photometer filtered to match characteristics of human eye.)	As required
Timing devices	As required
Measuring tape(s)	As required

Equipment required by applicable sections of TOP/MTP-3-2-814 3/

Equipment required for weapon-laying tests per TOP 3-2-603 4/

Equipment required for accuracy firing tests per TOP 3-2-605 5/

Low-light level TV camera

3. PREPARATIONS FOR TESTS.

3.1 Personnel and Equipment.

a. Use experienced driver, crew, and observer personnel.

1/, 2/, 3/, 4/, 5/, Footnote numbers match reference numbers in Appendix B.

*Values may be assumed to represent ±2 standard deviations except where indicated, thus the stated tolerances should not be exceeded in more than 1 measurement out of 20.

b. Use drivers and personnel operating sighting equipment that have known visual acuity, covering the spectrum.

c. Use personnel to operate sighting equipment who range from 5th through 95th percentile Army soldier in body dimensions which are critical to the performance of required tasks.

d. Use military personnel who are MOS qualified, school trained and attired in proper combat uniforms.

e. TOP 1-2-610 6/ contains further guidance on human factors tests.

3.2 Preparation of Test Vehicle.

a. Ensure that the test vehicle is in a combat ready condition checked in accordance with applicable technical manuals and stowed with the "on-vehicle equipment."

b. Inspect the test vehicle illuminating equipment for completeness and operability.

c. Perform basic tests of night vision devices, if any, in accordance with TOP/MTP 3-2-706.

d. Regulate the test vehicle electrical system for ordinary operation.

e. Measure and record the test vehicle power requirements as described in TOP 2-2-601. 7/

f. Record the following test vehicle and equipment identification data:

(1) Nomenclature of test vehicle and its primary and secondary armament and fire control system.

(2) Test vehicle model and serial number.

(3) Test vehicle inspection date.

4. TEST CONTROLS.

a. Observe all safety SOPs throughout the test.

b. Conduct night tests and day tests under the same weather and physical conditions.

c. Make practice runs prior to the test runs to insure that the equipment is functioning properly and that the test crew understands and can carry out the test procedures.

d. Establish test design to eliminate biases between drivers, vehicle type-configuration, test course terrain and light levels.

6/, 7/, Footnote numbers match reference numbers in Appendix B.

5. PERFORMANCE TEST.

5.1 Night Mobility. Evaluation of the adequacy of the night-driving provisions of a vehicle is accomplished by experienced personnel who operate a test item under various selected conditions, and register their opinions regarding the effectiveness, safety and adequacy of the item performance in formal questionnaires and/or task checklists (TECOM Pamphlet 602-1 8/ and appendix). The vehicle is driven over all types of terrain including trails, rough cross-country, secondary roads, and highways (TOP 2-2-506 9/) by operators experienced with the type of vehicle. The test vehicle follows, leads, and meets other vehicles in all test phases. A standard comparison vehicle is operated under the same conditions.

5.1.1 Method.

a. Simulate the traversing of unfamiliar terrain that one would encounter under combat conditions by using operators who have not driven the test course before the night test.

b. Traverse the course at night, and repeat the test on the same course with the same drivers at various ambient light levels from dark-full moon to dark-overcast and record light level for each run. In each case instruct the driver to operate at maximum safe speed.

c. Perform test runs first using headlights and other aids normally employed, and then repeat runs under blackout conditions using night vision aids provided. If there are neither night vision aids nor low-level illumination devices, such as blackout lights that provide some illumination, the blackout test need not be conducted.

d. Perform test runs in each course direction with each driver.

5.1.2 Data Required. Record the following:

a. Description, condition, and/or designation of test course covered.

b. Ambient light level for each run.

c. Average vehicle speed for each run.

d. Direction of traverse for each run.

e. Questionnaires/interview results for each run (Appendix C).

f. Driver identification and sighting equipment operator identification.

g. Descriptions of headlights, illuminating devices and night vision equipment employed on each run.

8/, 9/, Footnote numbers match reference numbers in Appendix B.

5.2 Interior Illumination. Tests to determine the adequacy of fighting compartment illumination are performed at night with experienced observer personnel replacing the crewmen. Observers should be careful not to interfere with illumination.

5.2.1 Method.

a. Perform the evaluation with the crew compartment closed and illuminated by normal overhead lights (white or near-white), if applicable, and with all observers in the crew positions and wearing crew clothing.

NOTE: Some types of combat vehicles are "open" type vehicles and, as such, are not equipped with overhead lights. For these vehicles perform only those evaluations which are applicable, but they should be performed under various levels of outdoor light.

b. Measure and record the level of illumination at each of the crew positions (identify each position) at those locations where the crew member must see something within the vehicle.

c. With three operators perform all the things necessary to fire the weapon without using live ammunition.

d. Repeat the test procedures with the crew compartment illuminated by blackout lights (red). Also see Data Required below.

5.2.2 Data Required. Record observer comments on the following:

a. Adequacy and effectiveness of illumination for performing duties such as map reading; weapon loading; operating systems controls; setting and reading turntable angles and locking handles; seeing and setting fuzes; seeing contents of ammunition ready racks; and seeing elevation and azimuth scales, where applicable.

b. Visibility of illuminated instruments such as:

(1) Warning lights.

(2) "Off-On" lights.

(3) Range scales.

(4) Level vials.

(5) Azimuth indicator rings.

(6) Boresight knob graduations.

(7) Control panels.

(8) Dials.

c. "Balance" of light on the components to avoid eye accommodation or adjustments when an observer's view is shifted from one unit to another.

5.3 Non-Firing Fire Control Tests. Night fire-control capability is evaluated for each sighting system, as applicable, considering angular resolution, target-detection range, weapon-laying and target-acquisition capabilities, and accuracy and dispersion of fire.

5.3.1 Angular Resolution. Where angular resolution is a factor in the optical system, tests are performed under various light levels including dark-overcast. Three experienced observers perform each test, with each observer making at least three sets of observations per test, alternating the sets.

NOTE: Angular resolution is the measure of the ability of a lens or optical system to form separate images of two points, relatively close together. No lens or optical system can form a perfect image of a point; the point will appear as a small disk surrounded by concentric circles. If two points are so close that the disks overlap and cannot be distinguished separately, they are not being resolved. The angle subtended by two points that are just far enough apart to permit resolution is termed the "limiting angle of resolution."

5.3.1.1 Method.

NOTE: An observation set will consist of two observations, one with the panels moved away from, and one with the panels moved toward, each other.

a. Position two white 25- by 25-cm panels against a black background, side by side, 100 meters from the objective of the sighting instrument.

b. Move the panels apart (equal distances) until the observer using the optical system can just detect two distinct panels.

c. See Paragraph 5.3.1.2 below.

d. Position the panels at equal distances from their original position (but at a greater distance than that measured in step b above).

e. Move the panels equal distances toward each other until separate images can no longer be detected by the observer.

f. See Paragraph 5.3.1.2 below.

NOTE: A more accurate technique of determining the resolving ability of daylight sights and night viewing devices is outlined in National Bureau of Standards, Circular 533, 20 May 1953. 10/ This method is recommended for use in a laboratory environment. Resolution data can be obtained only for a constant ambient light level with this method.

10/ Footnote numbers match reference numbers in Appendix B.

5.3.1.2 Data Required. Measure and record the ambient light level at the panels and the distance between the panels (inside edge to inside edge).

5.3.2 Range of Target Detection. Testing to determine the distance at which a clearly defined object can be detected with night fire control equipment is performed under various ambient light levels including dark-overcast. Standard visible light (i.e., daylight) sights are used for comparison. Observations are made by a team of three, with each observer making at least three sets of observations (as for the resolution tests, Paragraph 5.3.1) in alternated sets of two, one with the panel being moved away from, and one with the panel being moved toward, the vehicle.

5.3.2.1 Method.

a. Position one white, 25- by 25-centimeter panel against a black background 500 meters from the objective of the sighting instrument.

b. Move the panel away from the test vehicle until the maximum distance at which the panel is visible is determined.

c. See Paragraph 5.3.2.2.

d. Place the panel at a distance beyond the detection range measured in b above.

e. Move the panel toward the vehicle until the panel just becomes visible to the observers.

f. See Paragraph 5.3.2.2.

5.3.2.2 Data Required.

a. Measure and record light level at the panel and distance between sighting-instrument objective and panel.

b. Describe the night vision equipment or other optical equipment employed.

5.3.3 Weapon-Laying Capacity.

5.3.3.1 Method.

a. Perform in daylight as described in TOP 3-2-603.

b. Repeat under various light levels including dark-overcast.

c. See Paragraph 5.3.3.2b below.

5.3.3.2 Data Required.

a. Compare engagement times and laying errors, using night-sighting equipment and standard daylight visible sights.

b. Measure and record the following for each observation:

(1) Ambient light level outside the vehicle.

(2) Time to lay (obtained with a timer operated by an observer as described in TOP 3-2-603).

(3) Angular laying error, determined as follows: After the target is engaged with the night-sighting equipment, the target is illuminated and the weapon lay obtained with the daylight sights. The angular error inherent in the night weapon laying is recorded.

5.3.4 Target-Acquisition Capability.

5.3.4.1 Method.

a. Use three observers for each test, none with prior knowledge of target location or identity.

b. Position, at random, at least three, stationary, vehicular targets against the same natural background beyond the maximum detection range of any of the test vehicle sighting systems.

NOTE: Two of the targets shall be the same type of vehicle, such as: tanks, and large and small trucks.

c. Move the test vehicle toward the target area until target acquisition has been accomplished for all targets.

d. See Paragraph 5.3.4.2 below.

e. Emplace the targets in different positions against different backgrounds (both cluttered and uncluttered) and repeat the target-acquisition tests of steps c and d.

f. Repeat the target-acquisition tests for at least three moving targets selected in the same manner as the stationary targets (i.e., two of the same type to provide the degree of identification required) and record the target speed.

5.3.4.2 Data Required. Measure and record the following:

a. Target detection and recognition respectively.

b. Ambient light level at the target.

c. Identity of each target.

d. Background descriptions.

5.4 Firing Tests.

NOTE: It is not necessary to fire vehicle-mounted mortars at night since all of the necessary information can be obtained from nonfiring tests (Paragraph 5.2).

5.4.1 Method. Perform tests in various light levels, including dark-overcast, and under the following crew compartment lighting conditions.

a. Overhead lights (white, near-white).

b. Blackout lights (red).

c. No interior lighting.

d. For primary armament perform accuracy firing test as described in TOP 3-2-605 and record data indicated.

e. For secondary armament perform applicable prefiring checks, calibrations, adjustments and special accuracy firing tests as indicated in Table 1.

NOTE: Experienced observers monitor crew performance during reduced visibility and note particularly safety factors, ease of ammunition handling, manipulation of controls, and observation of targets (e.g., muzzle flash may impair crew vision). Observers should use formal task checklists when subjectively evaluating crew performance.

5.4.2 Data Required. Record the following information for each test:

a. Identity of the observer(s) and individual comments.

b. Crew compartment lighting used.

c. Ambient light level at start and finish of firing.

d. Ease of correcting malfunctions or stoppages, as applicable.

Table 1. Secondary Armament (Automatic Weapons)
Special Night Accuracy Firing Test

Test Number	Range (meters)	Ammo Groups*	Fire Control Method	Type of Fire	Type Target
1.	100	2	Tracer	5-round short Bursts	White 2.3 m square w/black 46 cm circular bull's-eye
2.	100	2	Sight		
3.	200	2	Tracer		
4.	200	2	Sight		
5.	400	4	Tracer	Continuous burst	White 6-m square w/black 2.3 m square in center w/white 46 cm circular bull's-eye
6.	400	4	Sight		
7.	600	4	Tracer		
8.	600	4	Sight		
9.	800	4	Tracer		
10.	800	4	Sight		
11.	1000	4	Tracer		
12.	1000	4	Sight		

*10 rounds per group.

e. Record test number from above table and other identifying data if necessary.

5.5 Durability of Illuminating Components and Night Vision Devices.

5.5.1 Method. Evaluate the durability of illuminating components and night vision devices during the overall endurance test of the test vehicle as described in TOP 2-2-506.

5.5.2 Data Required. Record the following for each component failure during the conduct of the test.

a. Component nomenclature.

b. Hours of component operation.

c. Hours of vehicle operation during component life.

d. For each type of terrain traversed, during component life.

(1) Total kilometers (miles).

(2) Total hours.

6. DATA REDUCTION AND PRESENTATION.

6.1 Night Mobility Evaluation.

a. Plot driving time versus ambient light level for each run at each exterior lighting condition.

b. Summarize questionnaires.

6.2 Night Fire-Control Evaluation.

6.2.1 Angular Resolution.

a. Compute the following for each observer at each ambient light condition for each viewing device:

(1) Average distance between panels, at resolution and loss of resolution.

(2) Average ambient light level at each lighting condition.

(3) Average limiting angle of resolution from the following formula:

$$\tan 1/2\ \theta = \frac{D}{2R}$$

where θ = limiting angle of resolution in mils

D = distance between panels in meters (average value from step 1 above)

R = target range in meters (feet)

b. Plot the average limiting angle of resolution versus the average ambient light level for each observer for each viewing device.

c. Plot to show comparison of resolution versus light level for both standard daylight sights and night-viewing devices.

6.2.2 Range of Target Detection.

a. Compute for each observer:

(1) Average range of target detection for panel moved away from and toward the vehicle, respectively.

(2) Average ambient light level at detection.

b. Plot maximum detection range versus ambient light level for both daylight- and night-viewing devices.

6.2.3 Weapon-Laying Capability.

a. Compute average angular laying error for each observer at each ambient light level for:

(1) Power controls.

(2) Manual controls.

b. Plot average standard deviation from time to lay at each position shown in Table I of TOP 3-2-603, for manual and power controls, at each ambient light level.

6.2.4 Target-Acquisition Capability.

a. Compute average ranges of target detection, target recognition, and target identification for each target-acquisition test at the light level at which observed.

b. Prepare plot showing above averages versus light levels for each target-acquisition test.

6.2.5 Firing Tests.

6.2.5.1 Primary Armament.

a. Present data reduction and presentation as described by the accuracy-of-fire and dispersion-of-fire sections of TOP 3-2-605.

b. Compute the average ambient light levels for each firing test at each ambient lighting condition.

c. Correlate firing results with average ambient light levels.

d. Correlate crew performance with crew compartment lighting condition.

e. Compare night-firing results with firing results presented in applicable section of TOP 3-2-605.

6.2.5.2 Secondary Armament.

a. Present firing results as required for each ambient lighting condition.

b. Compute the average ambient light level for each test number, at each ambient lighting condition.

c. Correlate firing results with carriage ambient light levels for fire control by tracer ammunition and fire control by sighting system.

d. Correlate crew performance with crew compartment lighting condition.

e. Compare applicable night-firing results with results of daylight firing conducted.

6.3 Durability of Illuminating Components and Night Vision Devices. Tabulate results and failure-frequence rates as applicable.

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APPENDIX A
BACKGROUND

Combat vehicle effectiveness at night is measured by the extent to which the vehicle can accomplish normal operations in the reduced light. Accordingly, the vehicle is tested for capability to negotiate the same terrain as in daytime and to meet target-detection and fire-control requirements. Illuminating components and active and passive night-vision devices (TOP/MTP 3-2-706) are tested for adequacy, and their electrical power demands on the vehicle determined. Tests are conducted at realistic ambient light levels from dark-full moon to dark-overcast.

The term "combat vehicle" includes tanks, self-propelled weapons, cargo/personnel carriers, and amphibious vehicles.

APPENDIX B
REFERENCES

1. TOP/MTP 3-2-706, Night Vision Devices, 24 June 1968.

2. TOP 1-1-011, Vehicle Test Facilities at Aberdeen Proving Ground, 17 March 1976.

3. TOP/MTP 3-2-814, Optical Collimation of Range Finders, 20 April 1966.

4. TOP 3-2-603, Gun Control Systems (Vehicular), 13 August 1976.

5. TOP 3-2-605, Accuracy Firing of Vehicular Weapons, 12 July 1977.

6. TOP 1-2-610, Human Factors Engineering (Part I - Procedures, Part II - HEDGE), 20 December 1977.

7. TOP 2-2-601, Electrical Systems (Vehicles and Weapon Subsystems), 20 June 1977.

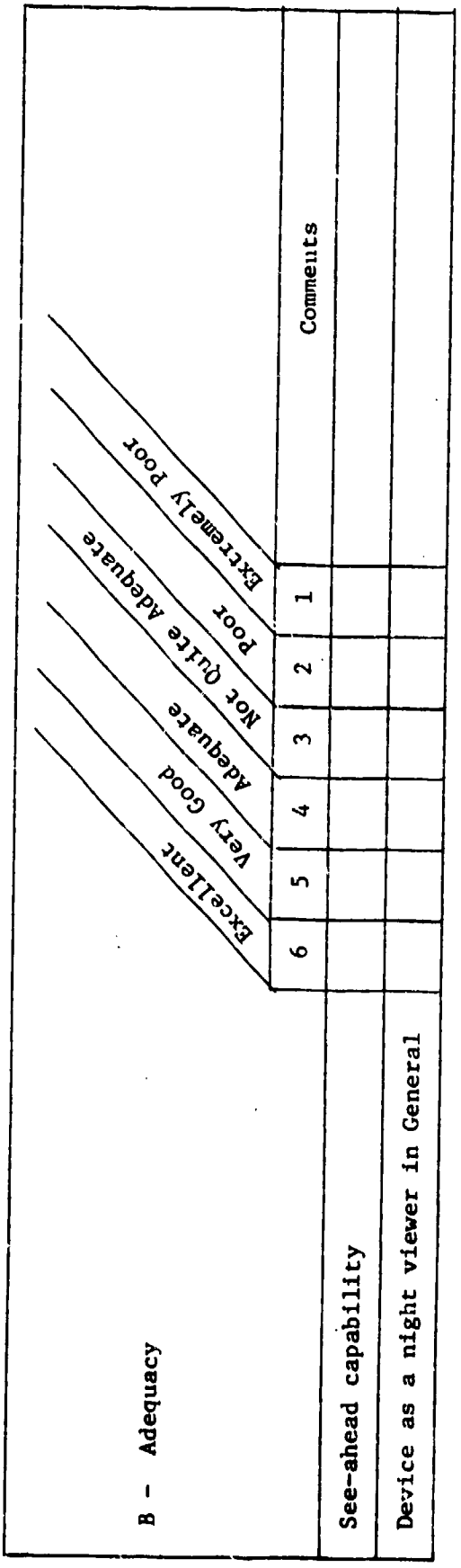
8. TECOM Pamphlet 602-1, Volume 1, 25 July 1975.

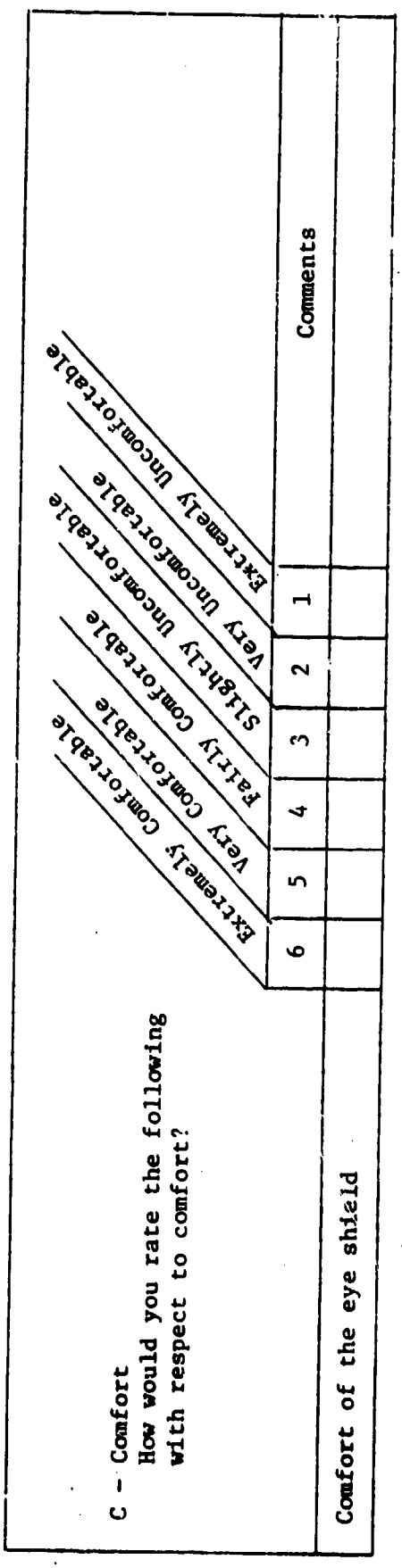
9. TOP 2-2-506, Endurance Testing of Tracked and Wheeled Vehicles, 9 September 1976.

10. National Bureau of Standards, "Circular 533," 20 May 1953.

APPENDIX C
SAMPLE QUESTIONNAIRES PERTAINING TO DRIVING

A - Task How would you rate the ease of performing the following tasks?	Extremely Easy 6	Very Easy 5	Easy 4	Difficult 3	Very Difficult 2	Extremely Difficult 1	Comments
Ability to see the course							
Ability to distinguish between shadows and deep holes							
Ability to identify objects							
Ability to identify obstacles							
Ability to see the edge of the road							
Ease of installing the viewer							
Ease of removing the viewer							


B - Adequacy
See-ahead capability
Device as a night viewer in General
Comments
1 Extremely Poor
2 Poor
3 Not Quite Adequate
4 Adequate
5 Very Good
6 Excellent


C - Comfort
How would you rate the following with respect to comfort?
Comfort of the eye shield
Comments
1 Extremely Uncomfortable
2 Very Uncomfortable
3 Fairly Comfortable
4 Very Comfortable
5 Extremely Comfortable
6

D - Answer Yes or No to Questions Below			
	Yes	No	Comments
Did the viewer interfere with vehicle operation?			
Did the viewer interfere with any other action while operating the vehicle?			
Did the AN/VVS-2m24 (viewer) interfere with exit from the vehicle?			
Did you experience headaches after use of the viewer?			

E - Human Factors Evaluation Checklist	Satisfactory	Unsatisfactory	Comments
Driver's ability to negotiate the course			
Driver's ability to identify and negotiate obstacles			
Driver's ability to stay on course/road			
Viewer compatibility with driver's operation of the vehicle			
Driver's ability to see the edge of the road with the viewer			